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What is the Long-term Outcome for Patients With Very Small Abdominal Aortic Aneurysms?

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Objective: *To determine the long-term outcome for patients with abdominal aortic aneurysms (AAA) less than 4 cm in AP diameter (very small AAA).*
Design: *Population-based screening study.*
Materials and methods: *One hundred and forty-two patients who had AAA less than 4 cm at presentation were assessed by ultrasound at intervals of 6–12 months. The records of these patients were reviewed.*
Results: *During the period of follow-up the median annual growth rate for aneurysms while under 3.0 cm was 1 mm, rising to 2 mm when between 3.0 and 3.9 cm, and 3 mm when between 4.0 and 4.9 cm in diameter. Elective aneurysm repair was undertaken when aneurysms exceeded the threshold value, which itself increased from 4 cm to 5.5 cm in the 9 years of follow-up. More patients died with their aneurysm (n=35) then underwent surgery (n=23). There was one perioperative death, and three unrelated late deaths after resection. One aneurysm ruptured in a patient who had refused follow-up 5 years previously.*
Conclusions: *This study suggests that aneurysms less than 4.0 cm diameter are relatively benign, and questions the appropriatness of early intervention.*

Key Words: Abdominal aortic aneurysm.

Introduction

The prevalence of abdominal aortic aneurysms (AAA) in otherwise healthy subjects has been estimated on many occasions; in Oxford the prevalence in healthy men 65–74 years of age is 5.4%.[1] Fifty-eight per cent of these are small aneurysms less than 4 cm. The prevalence is higher in patients with identifiable risk factors, such as hypertension.[2,3]

For large aneurysms of 5.5 cm and over most vascular surgeons would recommend surgery, as the annual risk of rupture exceeds the elective operative mortality rate in the absence of significant coexisting disease. The management of aneurysms between 4.0 and 5.4 cm diameter is less clear, and is currently the subject of investigation (the U.K. Small Aneurysms Trial and the Veterans Administration Trial[4,5]). What happens to the patients who are found to have aneurysms smaller than 4.0 cm? Our study addresses the question by following patients enrolled into surveillance programmes at Oxford and Gloucester, U.K.

Methods

AAA were detected during screening or after referral to the vascular services of the John Radcliffe Hospital, Oxford, or Gloucestershire Royal Hospital, Gloucester. Ultrasonography measurements were made of the maximum antero-posterior aortic diameter. The infrarenal aorta was defined as aneurysmal if its diameter was more than 5 mm wider than the aorta above the renal vessels. Only AAA of initial size below 4.0 cm were considered. Patients with only a single measurement, or two measurements less than 12 months apart, have been excluded from analysis.

Scans were performed every 6–12 months, with maximum follow-up of 9.5 years. The data were recorded contemporaneously on all patients. Mean annual growth rates (AGR) for each aneurysm were calculated by determining the increase in antero-posterior diameter while the aneursym was in each of

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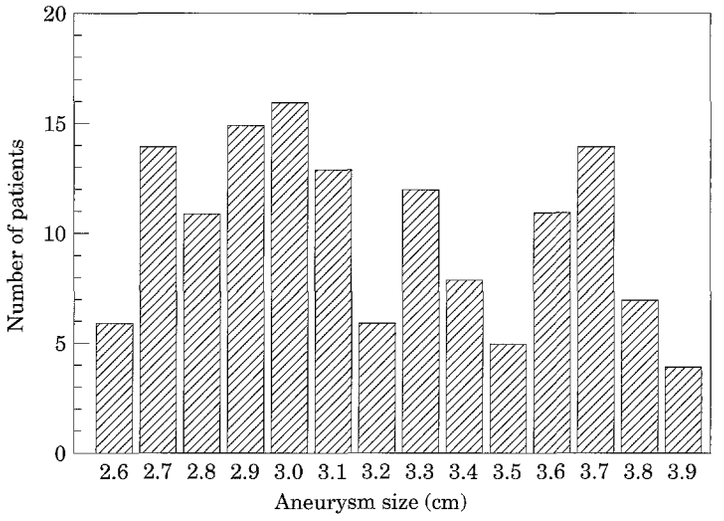

Fig. 1. Distribution of antero-posterior diameters at first examination.

three size bands (<3 cm, 3.0–3.9 cm, and 4.0–4.9 cm) at the previous measurement. The median AGR for a given size band was the median value of all the mean AGRs.

Results

Patients (Fig. 1)

One hundred and forty-two patients (131 male), median age 70 (range 43–86) at presentation, had serial scans of their AAA in the study period. The median follow-up was 48 months (range 12–114). Seven patients were discharged from follow-up with "non-enlarging" aortas, one at the patient's request, one moved from the area, and six were lost to follow-up. In a seventh, who died in hospital with an aneurysm of 5.7 cm, records cannot be found and the cause of death is unknown. Table 1 details these patients.

Deaths (Fig. 2)

Thirty-nine patients died, including three patients lost to follow-up with small aneurysms (2.8, 3.1, 3.3), and one who refused follow-up (diameter 3.7 cm) and presented 5 years later with a ruptured AAA and declined surgery. There was one perioperative death in a patient who underwent simultaneous resection of both thoracic and abdominal aortic aneurysms and died from multi-organ failure at 20 days. Three other patients died following surgery, one at 5 years from renal failure (she had a thoraco-abdominal aneurysm repaired for renal artery stenosis) and two from carcinoma of the lung, one at 7 months and one at 5 years. Figure 2 details the cause of death of the patients.

Surgery

Twenty-three patients underwent aneurysm resection at a median size of 5.0 cm (range 3.8–6.7). This includes one patient operated upon for a 5.0 cm iliac aneurysm with an aortic diameter of 3.8 cm. No patient under surveillance presented with a ruptured aneurysm, although one underwent resection for a tender 4.3 cm aneurysm. The low median size at time of surgery

Table 1. Details of patients discharged or lost to follow-up.

Patient number	Status	Age at first scan	Initial size	Final size	Duration of follow-up
1	Discharged	72	2.6	2.7	42
2	Discharged	66	2.5	2.8	18
3	Discharged	66	2.8	2.8	18
4	Discharged	70	2.6	2.9	42
5	Discharged	70	2.6	2.9	42
6	Discharged	69	2.9	2.9	12
7	Discharged	67	3.3	3.3	42
8*	Refused follow-up	73	3.4	3.7	18
9	Lost to follow-up	67	3.2	3.3	12
10	Lost to follow-up Died 3 years later	78	3.3	3.3	18
11	Lost to follow-up Died 2 years later	74	2.9	2.8	12
12	Lost to follow-up	70	2.5	2.6	12
13	Lost to follow-up	74	3.5	3.8	18
14	Lost to follow-up Died <2 years later	77	2.9	3.1	54

* Admitted with rupture 5 years later, refused operation and died.

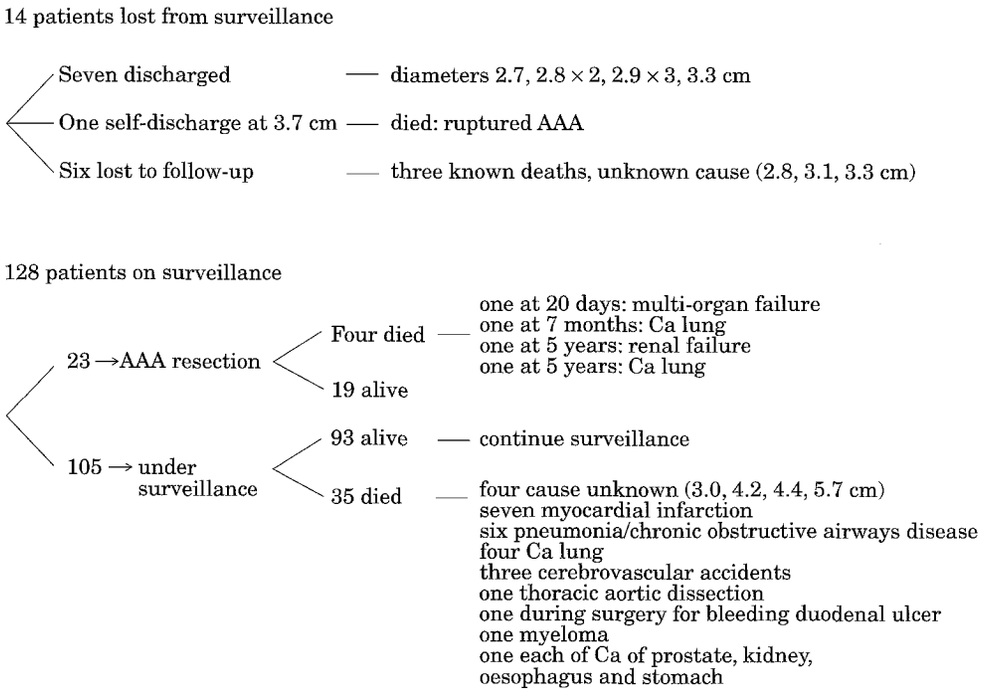

Fig. 2. Outcome diagram for the 142 patients in the study.

reflects unit policy in the early years of the study; the threshold for surgery has since risen (Fig. 3) and current policy considers surgery at aortic diameters over 5.5 cm. One patient recently underwent surgery with a 4.7 cm aneurysm which was mistakenly thought to be 6.0 cm.

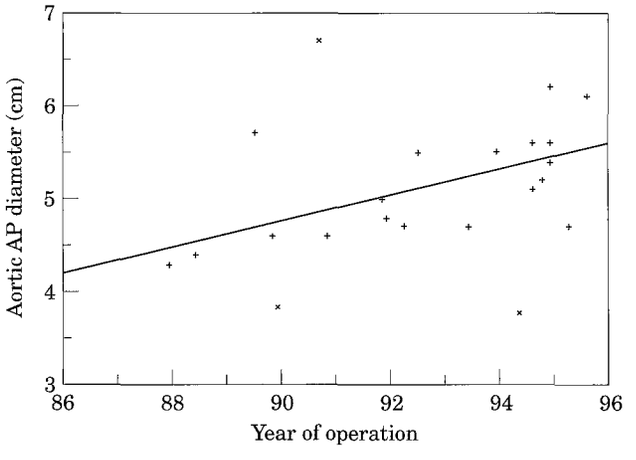

Fig. 3. Increasing threshold for surgery. The graph shows the aortic antero-posterior diameter at the time of surgery, illustrating how the threshold for surgery has increased during the period of follow-up. The line is the line of best fit between all the points, excluding three patients (denoted X) who were operated on for an iliac aneurysm, a thoraco-abdominal aneurysm and combined thoracic and aortic aneurysms.

Growth (Figs 4, 5 and 6)

Median annual growth rate was 1 mm for AAA less than 3.0 cm in AP diameter ($n=67$, range −2–18 mm), 2 mm while 3.0–3.9 cm ($n=110$, range −6–30 mm) and 3 mm while 4.0–4.9 cm ($n=51$, range −2–11 mm). For those aneurysms which underwent resection, growth rates were faster: 6 mm for AAA less than 3.0 cm ($n=3$), 5 mm while 3.0–3.9 cm ($n=20$) and 4 mm while 4.0–4.9 cm ($n=18$). Figure 5 shows the projected representative growth of an aneurysm starting at 2.5 cm, and exhibiting the median growth rates observed in each size range.

Overall there was a slight trend for aneurysms which grew quickly in the first year of surveillance to grow quickly in subsequent years (Fig. 6). The trend does not allow any prediction to be made about the future growth rates of an individual aneurysm.

Discussion

A major obstacle in any discussion of small aneurysms is the acceptance of a suitable definition. While most people would agree that an aortic diameter of 4 cm or greater was aneurysmal, there is less agreement regarding the lower cut off for an aneurysm.[6] Because the normal aorta tapers from above down, and the

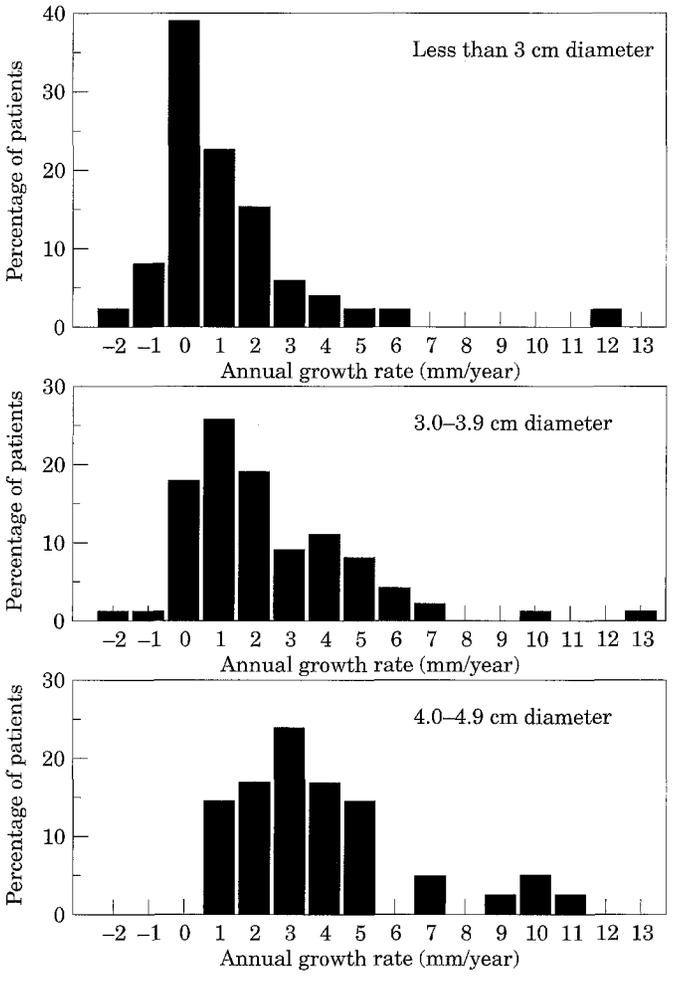

Fig. 4. Rates of aneurysm growth. Histogram plot showing the distribution of annual growth rates within each size band. Only aneurysms with at least 12 months' growth in the band are shown.

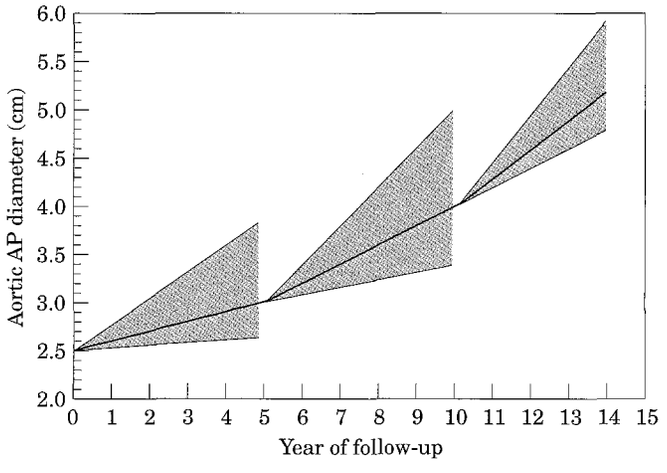

Fig. 5. Median aneurysm growth rate. Plot showing the diameter of an imaginary aneurysm growing in each size band according to the median annual growth rates, with the shaded areas between upper and lower quartiles for the band.

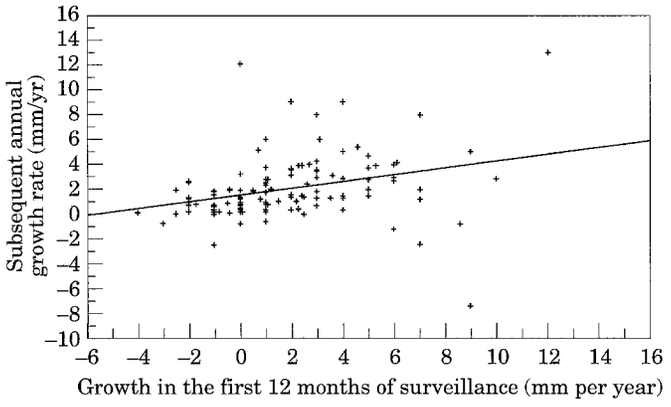

Fig. 6. Relationship between past and future growth. Graph showing the relationship between growth during the first 12 months of observation and the subsequent growth rate for aneurysms followed for at least 24 months. The line is the regression line between all points, and describes the function $y=1.5+0.3x$; $R^2=0.1$. Thus there is no significant relation between growth in the previous 12 months and future growth.

suprarenal aorta is bigger than the infrarenal aorta, the abdominal aorta should be considered aneurysmal (abnormally dilated) if it is wider in its infrarenal course than its suprarenal course. In our study, the aorta was defined as aneurysmal if its AP diameter was 5 mm or more greater than the diameter of the aorta at the diaphragm, where 5 mm corresponds to measurement error.[7] Of aortas under 3.0 cm in diameter, 39% did not grow to greater than 3.0 cm in a median follow-up of 5 years, and it could be argued that these were not in fact aneurysms at all. Indeed, many may have been the result of errors in measurement and recording, and the tolerance of the ultrasonography and ultrasonographers. However, three in the smallest size band (<3 cm) did grow rapidly and ultimately underwent surgery; one growing from 2.7 cm to 5.7 cm in just 4 years. Unfortunately, as we have illustrated here, previous growth rate cannot predict future growth for an individual aneurysm.

There is no commonly accepted way to measure growth rates. We followed the example of Sterpetti[8] in calculating rates for growth within a band, as this is the most readily applicable to clinical practice. The choice and width of band will influence the rate recorded: a wide band (3–5 cm for example) will be prone to exaggeration by a rapidly growing larger aneurysm, while inclusion of small sizes in a band will tend to lower growth rates. In order to provide sensible data, small bands containing large numbers of aneurysms are required, and it is for this reason that the two sets of data from Oxford and Gloucester were pooled, as both centres had similar policies for surveillance.

The small aneurysms as described here are typical of screen detected aneurysms. Two-thirds of the aneurysms detected by screening in Oxford are under 4 cm in diameter.[1] They are a common benign management problem, but surveillance *per se* is not necessarily benign. Patients are reminded at each visit of their "time bomb within", with inherent psychological effects. Surveillance is continued with the expectation that patients will come to surgery. Once the diameter reaches the threshold, surgery is advised and performed without delay. Concurrent disease may be missed or overlooked, especially if it has arisen since enrolment into surveillance. One patient died just 7 months following surgery from adenocarcinoma of the lung, emphasising the need to exclude other pathology, in particular vascular and smoking-related disease. Another risk from this 'expectation of surgery' is the rogue measurement, a rapid increase in growth which is not altogether unexpected and which may be acted upon without challenge. This series includes one such case successfully operated on for an aneurysm reported to have grown from 4.5 to 6 cm in 6 months, but which was actually shown to be only 4.7 cm on ultrasonography performed just before surgery.

If small aneurysms appear benign, why, then, is early surgery often advocated?[9] The principle reason appears to be in the perceived risk of rupture. Katz estimated a 3.3% per annum rupture risk of aneurysms under 4 cm in diameter,[9] although until the UK and Veterans Administration trials report there is no prospective information to support this estimate. No patient in our study suffered rupture of an aneurysm under 4 cm in diameter.

We have shown that small aortic anaeurysms are, in general, benign. Surveillance of growth may lead to early intervention, with the attendant operative morbidity and mortality. In the absence of symptoms the indication for elective aortic aneurysm replacement is prophylaxis against the risk of death from rupture

of the aneurysm. Larger aortic diameter and rapid rate of growth are believed to increase the annual risk of rupture. At present the annual risk of rupture for aneurysms under 5.5 cm diameter is unknown, and until better data are available on their natural history and the effect of rapid growth on risk, patients with small aortic aneurysms may have more to fear from vascular surgeons than from their aneurysms.

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